REMARKS

Applicant appreciates the Examiner's thorough consideration with respect to the present application. Claims 1, 3-7, 9, and 11-25 are currently pending. Claims 1, 5, 6, 9, 11, 13, 16 and 17 have been amended. Claims 1, 6, 9, 11 and 13 are independent. Claims 21-25 have been added for the Examiner's consideration. The subject matter of dependent claims 21-25 is fully supported by the original written description, including but not limited to, pages 5, lines 18 and 24; page 8, line 9; page 10, line 2; page 13, lines 4, 11 and 15; and page 16, lines 3, 7, 15 and 22.

Entry of the above amendments is earnestly solicited. Reconsideration of this application, as amended, is respectfully requested.

In addition, Applicant appreciates the courtesies of the telephonic interview conducted on December 19, 2002 between the Examiner and Applicant's representative. During the telephonic interview, the Examiner's objection to the term "crystal resonator" was discussed in greater detail and the basis for the rejection under 35 U.S.C. § 103(a) was also discussed in connection thereto. The details of the issues discussed during the telephonic interview are discussed in greater detail hereinafter under the appropriate headings.

Allowable Subject Matter

Applicant appreciates the Examiner's indication of allowable subject matter. Specifically, claims 9 and 11-20 have been allowed.

Claim for Priority

Applicant appreciates the Examiner's acknowledgment of the claim for foreign priority and the corresponding receipt of all of the certified copies of the priority documents.

Information Disclosure Statement

Applicant submits that it appears that the Examiner failed to initial one of the references listed on the Information Disclosure Statement timely filed on March 6, 2001. Specifically, Applicant requests that the Examiner forward a fully initialed 1449 indicating that Japanese patent document JP 3165236 has been considered by the Examiner. The Examiner is requested to contact the undersigned via telephone if there are any questions or concerns with respect to this issue.

Minor Informalities

The Examiner has objected to Applicant's use of the term crystal oscillator. Instead, the Examiner has requested that Applicant change this

term to read crystal --resonator-- to clarify the term throughout the specification for the benefit of the Examiner.

In light of the foregoing amendments to the specification and claims, Applicant submits that these objections to the claims and specification have been obviated and/or rendered moot. Without conceding the propriety of the Examiner's objection to this term, but merely to timely advance the prosecution of the present application, this term has been amended to recite crystal resonator where appropriate in the substitute specification submitted concurrently herewith.

Claim Rejections Under 35 U.S.C. § 103

Claims 1, 3 and 4-7 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kleinberg (U.S. Patent No. 4,862,114) in view of "The Electronic Circuit Parts Utilization Handbook" (Handbook reference hereinafter) cited by Applicant. This rejection is respectfully traversed.

In light of the foregoing amendments to the claims, Applicant submits that this rejection has been obviated and/or rendered moot. Applicant submits that the prior art of record fails to teach or suggest each and every element of the unique combination of elements of the claimed invention of claims 1, 3 and 4-7. Accordingly, these rejections should be withdrawn.

First, Applicant submits that the Examiner's interpretation of the Handbook reference appears improper. In the description of this reference, Fig. 5-11 is an inverter-type circuit, but the configuration of this circuit is different from that of the claimed invention of claims 1, 3 and 4-7. The inverter type high frequency oscillation circuits of claims 1 and 6 are not taught or described within the Handbook reference. Accordingly, this rejection appears improper and should be withdrawn.

Second, as seen in FIGs. 3(a) and 4(a) of the present application, the alleged inverter type circuit of the Handbook reference is different from the claimed invention. Further, the Kleinberg reference does not appear to teach or suggest inverter elements having the same function of the claimed invention. Accordingly, this rejection should be withdrawn.

Although Kleinberg appears to describe or show a Gate Amp., e.g., the circuit configuration in Fig. 2A of Kleinberg appears to be the description relied upon by the Examiner as the most relevant to the claimed invention, the condenser CL of the circuit configuration of Fig. 2A of Kleinberg appears purposefully added for the selection of oscillation frequency. In contrast, the claimed invention does not rely upon the use of a condenser to achieve or permit the selection of the oscillation frequency. Therefore, this rejection should be withdrawn.

Further, the oscillation circuit of the claimed invention of claims 1 and 6 produces unexpected and heretofore unknown beneficial effects. Specifically, even if the claimed circuit utilizes a crystal resonator having a basic frequency of between 1 to 500 MHz as its oscillation element, the claimed circuit is stable as it oscillates on the basic frequency. In the prior art, this stable oscillation could only be achieved by changing the oscillation circuit constant and the configuration for every oscillator.

Applicant respectfully submits that the prior art of record, either in combination together or standing alone, fails to teach or suggest the invention as is set forth by the claims of the instant application. Accordingly, reconsideration and withdrawal of the claim rejection are respectfully requested.

As to the dependent claims, Applicant respectfully submits that these claims are allowable due to their dependence upon an allowable independent claim, as well as for additional limitations provided by these claims.

CONCLUSION

All the stated grounds of rejection have been properly traversed and/or rendered moot. Applicant therefore respectfully requests that the Examiner reconsider all presently pending rejections and that they be withdrawn.

It is believed that a full and complete response has been made to the Office Action, and that as such, the Examiner is respectfully requested to send the application to Issue.

Attached hereto is a marked-up version of the changes made to the application by this Amendment.

In the event there are any matters remaining in this application, the Examiner is invited to contact the undersigned at (703) 205-8000 in the Washington, D.C. area.

Applicant respectfully petitions under the provisions of 37 C.F.R. § 1.136(a) and § 1.17 for a two-month extension of time in which to respond to the Examiner's Office Action. The Extension of Time Fee in the amount of **$410.00** is attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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Attachment: Version with Markings to Show Changes Made

MARKED-UP VERSION OF THE AMENDMENTS

IN THE SPECIFICATION:

A substitute specification has been submitted concurrently herewith.

IN THE CLAIMS:

The claims have been amended as follows:

1. (Thrice Amended) A high-frequency oscillation circuit comprising:

a closed loop circuit including at least one logic element, said at least one logic element having an input and an output, wherein said closed loop circuit begins at said output and returns to said output of said at least one logic element, said at least one logic element including a first logic element within said closed loop circuit;

another logic element external to said closed loop circuit;

a capacitor being disposed within said closed loop circuit;

a resistor being disposed within said closed loop circuit; and

a crystal [oscillator] <u>resonator</u> for high frequency being disposed within said closed loop circuit, said crystal [oscillator] <u>resonator</u> being connected in series with said capacitor and in parallel with said resistor and having a basic oscillation frequency of between 1 MHz to 500 MHz.

5. (Thrice Amended) A high-frequency oscillation circuit as claimed in claim 1, wherein said crystal [oscillator] resonator of high frequency has a basic oscillation frequency of at least 30 MHz.

6. (Thrice Amended) A high-frequency oscillation circuit comprising:

a closed loop circuit including at least one logic element, said at least one logic element having an input and an output, wherein said closed loop circuit begins at said output and returns to said output of said at least one logic element, wherein said at least one logic element includes a first logic element within said closed loop circuit and another logic element external to and in serial connection with said closed loop circuit, said first logic element including a high speed CMOS or a high speed TTL;

a capacitor being disposed within said closed loop circuit;

a resistor being disposed within said closed loop circuit; and

a crystal [oscillator] resonator for high frequency being disposed within said closed loop circuit, said crystal [oscillator] resonator being connected in series with said capacitor and in parallel with said resistor.

9. (Thrice Amended) A high-frequency oscillation circuit comprising:

a closed loop circuit including at least one logic element, said at least one logic element having an input and an output, wherein said closed loop circuit

begins at said output and returns to said output of said at least one logic element, said at least one logic element including a first logic element within said closed loop circuit;

another logic element external to said closed loop circuit;

a capacitor being disposed within said closed loop circuit;

a resistor being disposed within said closed loop circuit; and

a crystal [oscillator] resonator for high frequency being disposed within said closed loop circuit, said crystal [oscillator] resonator being connected in series with said capacitor and in parallel with said resistor, wherein said crystal [oscillator] resonator is a sensor element for chemical measurement of a predetermined parameter.

11. (Twice Amended) A high-frequency oscillation circuit comprising:

a closed loop circuit including at least one logic element, said at least one logic element having an input and an output, wherein said closed loop circuit begins at said output and returns to said output of said at least one logic element, wherein said logic element includes a high-speed TTL or CMOS;

a capacitor being disposed within said closed loop circuit;

a resistor being disposed within said closed loop circuit; and

a crystal [oscillator] resonator for high frequency being disposed within said closed loop circuit, said crystal [oscillator] resonator being connected in

series with said capacitor and in parallel with said resistor, said crystal [oscillator] resonator having a basic oscillation frequency of 500 MHz or more.

13. (Amended) A measuring instrument for measuring a predetermined parameter, said measuring instrument comprising:

a closed loop, high frequency oscillation circuit including at least one logic element, said at least one logic element having an input and an output, wherein said closed loop circuit begins at said output and returns to said output of said at least one logic element;

a capacitor being disposed within said closed loop circuit;

a resistor being disposed within said closed loop circuit; and

a sensor for determining said predetermined parameter, wherein said sensor includes a crystal [oscillator] resonator for high frequency being disposed within said closed loop circuit, said crystal [oscillator] resonator being connected in series with said capacitor and in parallel with said resistor and having a natural oscillation frequency, a change in said natural oscillation frequency of said crystal [oscillator] resonator being indicative of said predetermined parameter.

16. (Amended) The measuring instrument for measuring said parameter according to claim 15, said crystal [oscillator] resonator having a basic oscillation frequency of 500 MHz or more.

17. (Amended) The measuring instrument for measuring said parameter according to claim 15, said crystal [oscillator] resonator having a basic oscillation frequency of between 1 MHz and 500 MHz.

Claims 21-25 have been added.

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SPECIFICATION

HIGH-FREQUENCY OSCILLATION CIRCUIT

FIELD OF THE INVENTION

The present invention relates to a high-frequency oscillation circuit, and more particularly, to a high-frequency oscillation circuit useful for enhancing sensitivity of various measuring instruments used as weight sensor, chemical sensor, biosensor, viscosity sensor, film thickness meter, gas sensor, floating dust sensor, immunity sensor or the like.

BACKGROUND OF THE INVENTION

While recently various measuring instruments using crystal as weight sensor, chemical sensor, biosensor, viscosity sensor, film thickness meter or the like have been numerously developed, it has been needed urgently to develop a high precision and highly sensitive measuring instruments to cope with such a demand for diversity of materials to be detected and precise quantitative determination of materials to be detected.

As is generally known, however, a wafer used for a crystal [oscillator] resonator has such a nature as to cause distortion (piezo-electric effect) when a voltage is

applied to thin film electrodes attached to both side faces faces thereof and return to its initial state when the voltage is removed. Because of this nature, a crystal [oscillator] resonator oscillates at a natural frequency determined by its thickness. Thereby, in a crystal wafer, when its thickness varies by adsorbing a substance, a basic frequency (i.e., the natural oscillation frequency or basic oscillation frequency) of the crystal [oscillator] resonator is varied.

The change Δf of this natural oscillation frequency is proportionate to a change in thickness. If the change in thickness dimension is replaced by a change Δm in mass, the following equation called Sauerbrey's equation can be introduced.

$$\Delta f = -\{2f_0^2/(\rho q \times \mu q)^{1/2}\} \times (\Delta m/A)$$

wherein f_0 is a basic oscillation frequency, ρq and μq are density and elastic modulus of the crystal, respectively, and A is the area of a portion performing piezo-electric response.

From this equation, it is understood that, since the sensitivity Δf is proportionate to the square of the basic oscillation frequency f_0, it is desirable to use a crystal [oscillator] resonator whose f_0 is great. However, if f_0 becomes too great, the thickness is reduced, and the [oscillator] resonator tends to be easily broken.

Therefore, it is general to use a crystal [oscillator] resonator whose f_0 is between 5 and 10 MHz under the normal atmosphere, and even in a solution, merely a crystal [oscillator] resonator whose greatest oscillation frequency f_0 is 30 MHz is used, and a measurement exceeding the maximum detection limit of a general-purpose crystal [oscillator] resonator has not yet been attained.

While there is also an example of measurement using the seventh order overtone mode (63 MHz) of a crystal [oscillator] resonator whose f_0 is 9MHz, its detection limit is reported as 0.1 ng, which showed no remarkable improvement in sensitivity, compared with the conventional method of 1 ng ("The Latest Method of Separation, Purification and Detection", p. 441, by NTS Publishing Co., issued May 26, 1997).

On the other hand, in contrast with such a situation as above, there is also proposed a high-frequency oscillation circuit using a crystal [oscillator] resonator not as a weight sensor but for controlling the frequency of an oscillation circuit.

However, in many cases these circuits were analog circuits which are complicated and hard-to-adjust as numerous parts such as transistor, coupling transformer, inductance, etc., are used, and were expensive and not

suitable to be used as a measuring instrument for various sensors.

A low-frequency oscillation circuits using a logic element in part is known (JP-A-3-165236 ("JP-A" means unexamined published Japanese patent application), "The Electronic Circuit Parts Utilization Handbook", p.67, by CQ Publishing Co., issued on November 1, 1985). This oscillation circuits, however, use only an [oscillator] resonator having a natural frequency in a low-frequency area, so that it cannot cope with a demand for higher sensitivity, making it hard to realize a high-frequency oscillation circuit showing high-frequency stability. Furthermore, there was a need to design and constitute an oscillation circuit to suit a crystal [oscillator] resonator to be oscillated and its frequency (Japanese patent application No. 2000-31513).

SUMMARY OF THE INVENTION

The present invention overturns common knowledge of a conventional oscillation circuit.

The present invention aims to provide a high-frequency oscillation circuit which can keep a stable high-frequency oscillation to easily cope with the natural oscillation frequency of a crystal [oscillator] resonator as a sensor

even if it becomes high, and yet which can be easily manufactured at a low cost.

Other and further objects, features, and advantages of the invention will appear more fully from the following description, take in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1(a) is a diagram showing an embodiment of a high-frequency oscillation circuit using a logic element "NAND" and a crystal [oscillator] resonator having a basic oscillation frequency of 50 MHz.

Fig. 1(b) is a graph showing an oscillation waveform of the circuit in Fig. 1(a).

Fig. 2(a) is a diagram showing an embodiment of a high-frequency oscillation circuit using a logic element "NAND" and a crystal [oscillator] resonator having a basic oscillation frequency of 100 MHz.

Fig. 2(b) is a graph showing an oscillation waveform of the circuit in Fig. 2(a).

Fig. 3(a) is a diagram showing an embodiment of a high-frequency oscillation circuit using a logic element "inverter" and a crystal [oscillator] resonator having a basic oscillation frequency of 155 MHz.

Fig. 3(b) is a graph showing an oscillation waveform of the circuit in Fig. 3(a).

Fig. 4(a) is a diagram showing an embodiment of a high-frequency oscillation circuit using a logic element "inverter" and an overtone crystal [oscillator] resonator of 100 MHz.

Fig. 4(b) is a graph showing an oscillation waveform of the circuit in Fig. 4(a).

Fig. 5 is a graph showing the stability of an oscillation frequency per hour of the circuit shown in Fig. 2(a) in case of using a normal crystal [oscillator] resonator.

Fig. 6 is a graph showing the stability of an oscillation frequency per hour of the circuit shown in Fig. 2(a) in case of using a crystal [oscillator] resonator on which a styrene film was deposited for one minute by the plasma polymerization method.

Fig. 7 is a diagram showing another embodiment of the high-frequency oscillation circuit of the present invention.

Fig. 8(a) is a graph showing an oscillation waveform measured by oscilloscope in case a crystal [oscillator] resonator having a basic oscillation frequency of 20 MHz is used in the circuit shown in Fig. 7.

Fig. 8(b) is a graph showing an oscillation waveform measured by oscilloscope in case a crystal [oscillator] resonator having a basic oscillation frequency of 33 MHz is used in the circuit shown in Fig. 7.

Fig. 8(c) is a graph showing an oscillation waveform measured by oscilloscope in case a crystal [oscillator] resonator with a basic oscillation frequency of 50 MHz is used in the circuit shown in Fig. 7.

Fig. 8(d) is a graph showing an oscillation waveform measured by oscilloscope in case a crystal [oscillator] resonator having a basic oscillation frequency of 155 MHz is used in the circuit shown in Fig. 7.

Fig. 9(a) is a graph showing changes in the oscillation frequency with the lapse of time when one of the oscillation circuits of Fig. 7 is used and saturated acetone steam of the same concentration is adsorbed on crystal [oscillators] resonators coated with a plasma polymerized styrene film of the same weight.

Fig. 9(b) is an enlarged graph of the measurement result by using the crystal [oscillator] resonator having the basic oscillation frequency of 9 MHz in Fig. 9(a).

DETAILED DESCRIPTION OF THE INVENTION

Studying hard to solve the foregoing problems, the inventor used a readily available logic element, made a

closed circuit by connecting its input and output with a capacitor, a resistor and a crystal [oscillator] <u>resonator</u> having a natural oscillation frequency in a high-frequency area, and discovered that an oscillation circuit capable of keeping a more stable high-frequency oscillation can be unexpectedly obtained by the operation time or response speed of the logic element, the time constant of the capacitor and the resistor or the like, resulting in completion of the present invention.

The present invention provides a high-frequency oscillation circuit characterized by incorporating a crystal [oscillator] <u>resonator</u> having a natural oscillation frequency (i.e., basic oscillation frequency) in a high-frequency area into a closed circuit including a logic element.

In the present invention, a closed circuit is formed by using a logic element. It is possible to use a readily available logic element such as NAND circuit, NOR circuit, inverter or the like which is heretofore publicly known, but it is preferable to use a high-speed TTL (Transistor-Transistor Logic) element or CMOS (Complementary Metal Oxide Semiconductor) element so as to cope with a high-frequency oscillation. Also, in a high-frequency oscillation circuit into which a crystal [oscillator] <u>resonator</u> having a basic oscillation frequency in a high-

frequency area is incorporated, it is possible to use a logic element CMOS, which is fast in the response speed, so as to cope with the high frequency.

As a crystal [oscillator] resonator having a natural oscillation frequency in a high-frequency area, a crystal [oscillator] resonator having a natural oscillation frequency corresponding to the oscillation frequency of the circuit generally between 30 and 1800 MHz, preferably between 50 and 1800 MHz, more preferably between 100 and 1800 MHz, and the most preferably between 150 and 1800 MHz can be given. As another crystal [oscillator] resonator for high frequency, a crystal [oscillator] resonator having a basic oscillation frequency corresponding to an oscillation frequency generally between 1 MHz and 2GHz, preferably of 150 MHz or more can be given as an example.

In the high-frequency oscillation circuit relative to the present invention, it is possible to incorporate a crystal [oscillator] resonator having a basic oscillation frequency in a high-frequency area into a closed circuit including a high-frequency CMOS as a logic element. This oscillation circuit has quite a novel circuit content and circuit constitution of a type that could not be anticipated or expected by the conventional electronic circuit. Such a high-frequency oscillation circuit as this is suited for oscillation of an [oscillator]

resonator, particularly a crystal [oscillator] resonator for chemical measurement.

The closed circuit in the present invention can be formed by connecting a capacitor, a resistor and a crystal [oscillator] resonator having a natural oscillation frequency in a high-frequency area to the input and output of such a logic element, and properly adjusting an operation time or response speed of the logic element, the natural oscillation frequency of the crystal [oscillator] resonator, and the time constant or the like of the capacitor and resistor.

As a concrete circuit constitution of the closed circuit, such an embodiment as one using, for example, two NANDs or one inverter can be given. However, in view of a sustained oscillation property of a stable high oscillation frequency, an embodiment to select a high-speed TTL or CMOS to suit the natural oscillation frequency in a high-frequency area of the crystal [oscillator] resonator incorporated into the closed circuit, or an embodiment to select a logic element CMOS having a response speed capable of coping with the basic oscillation frequency in the high-frequency area is preferable.

As another preferable embodiment of the present invention, the following embodiments can be mentioned.

(1) A high-frequency oscillation circuit having high-frequency stability, which comprises a crystal [oscillator] resonator for high frequency disposed within a closed circuit that is formed with a logic element, and (2) A high-frequency oscillation circuit, which comprises a crystal [oscillator] resonator having a basic oscillation frequency in a high frequency area, in a closed circuit that is formed so as to connect the input and output of a logic element.

PREFERRED EMBODIMENTS OF THE INVENTION

In the following, the present invention is described in more detail, but the invention is not limited thereto.

Embodiments 1

The high-frequency oscillation circuits, in case a logic element NAND is used, are shown in Figs. 1 and 2, respectively. Fig. 1(a) shows an example of an oscillation circuit when a crystal [oscillator] resonator X1 for a basic frequency of 50 MHz is used; Fig. 1(b) shows an oscillation waveform of the same circuit as measured by using an oscilloscope. Fig. 2(a) shows an example of an oscillation circuit when an overtone (oscillation frequency of a sub-oscillation) crystal [oscillator] resonator X2 in the 3rd or 5th order of 100

MHz is used; Fig. 2(b) shows an oscillation waveform of the same circuit as measured by using an oscilloscope.

In Fig. 1(a) and Fig. 2(a), IC1 - IC3 are NANDs as logic elements, X1 is a crystal [oscillator] resonator having a basic oscillation frequency of 50 MHz, X2 is a crystal [oscillator] resonator having a basic oscillation frequency of 100 MHz, C1 - C3 are capacitors, and R1 - R2 are resistors.

Each closed circuit is constituted by connecting the output of the logic element IC1 to the input of IC2, and connecting the output of IC2 to the input of IC1. IC3 is a buffer for taking out the output of the oscillation circuit to the outside. In each of closed circuits a crystal [oscillator] resonator X1 or X2 is disposed. The impedance of each of the crystal [oscillators] resonators X1 and X2 becomes the lowest at their natural oscillation frequencies (i.e., basic oscillation frequencies).

Consequently, in each oscillation circuit, each capacitor C and each resistor R are set at such a value as the circuit impedance has the lowest value where the impedance of the crystal [oscillator] resonators X1 or X2 is the lowest, in view of the operating speed of the logic element IC.

The values of the above circuit components (parts) and the names of the logic elements are shown in Fig. 1(a) and

Fig. 2(a), respectively. In Fig. 1(a), the type of the logic elements IC1, IC2 and IC3 are 74LS00; C1 is 10pF; C2 is 7pF; C3 is 100pF; R1 is 470Ω; and R2 is 330Ω. In Fig. 2(a), the type of the logic elements IC1, IC2 and IC3 are 74HC00; C2 is 1pF; C3 is 100pF; R1 and R2 are 300Ω.

However, such values of the circuit parts and names of the logic elements are not absolute, and since the impedance of the circuit is low enough in their vicinities, the circuit will oscillate at the natural oscillation frequencies of the crystal [oscillators] <u>resonators</u> X1 or X2.

As are clear from Fig. 1(b) and Fig. 2(b), in each of the oscillation circuits shown in Figs. 1 and 2, the waveform at the above circuit constants takes a substantially pure sine wave and can be measured accurately enough by an ordinary frequency counter.

<u>Embodiments 2</u>

Next, oscillation circuits, in case an inverter is used as a logic element, are shown in Figs. 3 and 4, respectively. Fig. 3 shows an example of using a crystal [oscillator] <u>resonator</u> X1 having a basic oscillation frequency of 155 MHz. Fig. 4 shows an example of using an overtone crystal [oscillator] <u>resonator</u> X2 in the 3rd or 5th of 100 MHz.

Each symbol is the same as in Embodiments 1. The logic element IC is an inverter and L1 is an inductance. Also, IC2 is a buffer to take out the output of the oscillation circuit outside. In each oscillation circuit, a closed circuit is constituted by connecting the input and output of the inverter IC1. The crystal [oscillator] <u>resonator</u> X1 or X2 is disposed in this closed circuit. The impedance of each of the crystal [oscillators] <u>resonators</u> X1 and X2 becomes the lowest at their natural oscillation frequencies. Consequently, each oscillation circuit oscillates at the natural oscillation frequency of the crystal [oscillator] <u>resonator</u> X1 or X2.

Fig. 3(a) shows an example of a circuit which excites the optimum oscillation at the basic oscillation frequency of the crystal [oscillator] <u>resonator</u> X1. The basic oscillation frequency of the crystal [oscillator] <u>resonator</u> X1 in this example is 155 MHz. The values of the capacitor C1 and the resistor R1 which are concrete circuit parts as well as the name of the logic element IC are shown in the drawing.

Fig. 4(a) shows an example of a circuit which oscillates the most favorably at each overtone. C1 and L1 are for selecting a desired order. The drawings show the value of the circuit parts and the name of the logic element in case the circuit is oscillated at the natural

oscillation frequency of 100 MHz by using the 5th order (or 3rd order of 33 MHz) of the crystal [oscillator] <u>resonator</u> X2 having the basic oscillation frequency of 20 MHz.

In Fig. 3(a), the type of the logic elements IC1 and IC2 are 74HCU04AP; C1 is 50pF; R1 is 500kΩ; and L1 is 0.5μH. In Fig. 4(a), the type of the logic elements IC1 and IC2 are 74HCU04; C1 is 150pF; R1 is 100Ω; and L1 is 0.5μH.

These value of the circuit parts and name of logic element are not definite, but it is the same as in case of Embodiments 1 in that, if a value is in the vicinity, the impedance of the circuit is low enough, so the circuit will oscillate at the natural oscillation frequency of the crystal [oscillator] <u>resonator</u> X1 or X2.

As are clear from Fig. 3(b) and Fig. 4(b), in each of the oscillation circuits, the waveforms at the above circuit constant show a substantially pure sine wave, and the frequency can be measured accurately enough by an ordinary frequency counter.

Fig. 5 shows the degree of stability of the oscillation frequency in an hour in case of the circuit having the oscillation frequency of 100 MHz using an ordinary crystal [oscillator] <u>resonator</u>, in the Embodiment shown in Fig. 2(a). Fig. 6 shows the degree of stability

of the oscillation frequency in an hour in case of the circuit using a crystal [oscillator] resonator on which a styrene film is deposited for one minute by a plasma-polymerization method, in which the circuit having an oscillation frequency of 100 MHz is the same one of the embodiment as shown in Fig. 2(a).

It will be understood from Fig. 5 that, by maintaining constant the temperature of each of oscillation circuits mentioned in Embodiments 1, the variation in oscillation frequency of the circuit per hour is of a value within the range of 10 Hz. Further, as shown in Fig. 6, the variation in oscillation frequency per hour of the circuit using the crystal [oscillator] resonator on which a styrene film is deposited for one minute by plasma polymerization method is also within the range of 10 Hz.

It is also confirmed that each of the circuits in Embodiments 2 shows the same oscillation property of a highly stable high-frequency as in Embodiments 1.

Embodiment 3

A high-frequency oscillation circuit using an inverter as a logic element is shown in Fig. 7. Fig. 7 shows an oscillation circuit using a crystal [oscillator] resonator whose basic oscillation frequency is between 20 MHz and 155 MHz.

In Fig. 7, IC1 and IC2 are inverters as logic elements; X is a crystal [oscillator] resonator; C is a capacitor; and R is a resistor. The concrete values of the capacitor C and the resistor R and the name of the logic element IC are shown in the drawing. Further, IC2 is a buffer to take out the output of the oscillation circuit outside.

In this oscillation circuit, a closed circuit is constituted by connecting the input and the output of the inverter IC1. The crystal [oscillator] resonator X is placed in this closed circuit. The impedance of the crystal [oscillator] resonator X becomes the lowest at its basic oscillation frequency. Accordingly, the circuit will oscillate at the natural oscillation frequency of the crystal [oscillator] resonator X. For instance, the oscillation frequency can be 1 to 19 MHz, 20 MHz, 33 MHz, 50 MHz, and 155 MHz in the circuit of Fig. 7.

In Fig. 7, the type of the inverter IC1 and IC2 is 74HCU04AP; R is 500 kΩ; and C is 1000 pF.

The above values of the circuit elements and the names of the logic elements are not restrictive, but, since the impedance of the circuit is low enough in the vicinities, the oscillation circuit oscillates at the basic oscillation frequency of the crystal [oscillator]

resonator X. It is desirable to select a logic element CMOS capable of coping with this range of frequency.

Fig 8(a), (b), (c) and (d) show output waveforms measured by an oscilloscope in case crystal [oscillators] resonators X having basic oscillation frequencies of 20 MHz, 33 MHz, 50 MHz, and 155 MHz are respectively used in the circuit of Fig. 7. As is clear from each Figure, the output waveform by the above circuit constant has a shape between a rectangular and a sine wave and shows approximately a sine wave at 155 MHz. The oscillation frequency of the oscillation circuit showing these output waveforms can be sufficiently measured by an ordinary frequency counter.

Thus, by selectively using one of crystal [oscillator] resonators X having various basic oscillation frequencies from 1 MHz to 2 GHz, they can be oscillated on the same circuit at the basic oscillation frequency of each crystal [oscillator] resonator. Conventionally, it has been a common knowledge to design and constitute an oscillation circuit the most favorable for each crystal [oscillator] resonator. The present invention overturns the common knowledge regarding conventional oscillation circuits.

Figs. 9(a) and 9(b) show changes in the oscillation frequency with the lapse of time when one of the oscillation circuits of Fig. 7 is used and saturated

acetone steam of the same concentration (as measured by extracting 2 ml of head space of the acetone solution and injecting it into a gas adsorption measurement vessel of 1000 ml) is adsorbed on crystal [oscillator] resonators (of 9 MHz, 50 MHz, 155 MHz) coated with a plasma polymerized styrene film of the same weight (subjected to electric discharge output of 100 W, monomer pressure of 100 Pa, and 1 minute of polymerization time).

In Figs. 9(a) and 9(b), gas adsorption responses are shown, when measured, respectively, by using: (●) a crystal [oscillator] resonator having a basic oscillation frequency of 9 MHz; (○) a crystal [oscillator] resonator having a basic oscillation frequency of 50 MHz; and (▼) a crystal [oscillator] resonator having a basic oscillation frequency of 155 MHz. As the basic oscillation frequencies of the crystal increase, the amount of change in frequency responding to the acetone steam of the same concentration remarkably increases.

In Figs. 9(a) and 9(b), the average values of gas adsorption at respective frequencies show frequency responses of 30 Hz in case of 9 MHz (●), 1200 Hz in case of 50 MHz (○), and 2500 Hz in case of 155 MHz (▼), respectively. Evidently, the higher the basic oscillation frequency of a crystal [oscillator] resonator used for gas

adsorption is, the greater amount of response by gas adsorption is shown.

In the high frequency oscillation circuit shown in Fig. 7, it is not necessary to change the circuit constant in correspondence to the basic oscillation frequency of the crystal [oscillator] resonator to be used. With such an oscillation circuit, it is possible to cope with as it is, even if a crystal [oscillator] resonator as a sensor is changed according to purposes of measurement so as to change a basic frequency, which was heretofore difficult. If such a high-frequency oscillation circuit is used, a precision high-sensitive measuring instrument which is the most favorable for measurement of a super-high sensitive gas sensor or the amount of floating dust can be readily fabricated.

The high-frequency oscillation circuit using the logic elements according to the present invention, though using inexpensive parts and being a simple circuit, continues highly stable oscillation by a crystal [oscillator] resonator having a high natural oscillation frequency.

As a result, the high-frequency oscillation circuit of the present invention enables to measure precisely a delicate change in natural oscillation frequency of a crystal [oscillator] resonator as a sensor, and a use of such a high-frequency oscillation circuit enables to

readily fabricate a super-high-sensitive, precision measurement instrument favorable for measurement such as a super-high sensitive weight sensor, a viscosity sensor, and the like.

Having described our invention as related to the present embodiments, it is our intention that the invention not be limited by any of the details of the description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

ABSTRACT OF THE DISCLOSURE

A high-frequency oscillation circuit incorporates a crystal [oscillator] resonator having a natural oscillation frequency in a high-frequency area within a closed circuit including one or more logic elements. Therefore, this circuit copes with an oscillation frequency of 1 MHz to 2 GHz or more in basic oscillation frequency of a crystal [oscillator] resonator and it oscillates with stability at the basic oscillation frequency of the crystal [oscillator] resonator.